IX.

ON THE ORIGIN AND FORMATION OF ICE ISLANDS AND THEIR DANGEROUS EFFECTS IN NAVIGATION;

Pointing out a certain and easy method of timely forewarning seamen of their approach, even in the darkest nights.

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——DIES DOCEAT——
INTERIM "CAUTELA NON NOCET."

On their origin and formation.

AS no philosophical work expressly written on the origin and formation of ice islands has yet appeared, the subject may be considered in a great measure as untouched. The present attempt, with so few materials, will doubtless be deemed as bold as it is novel. It is therefore not without diffidence, that I venture to lay it before this learned society, whose candour, however, will plead for its imperfections.

These enormous bodies are distinguished by mariners according to their apparent magnitude into continents, islands, and fields of ice, extending often to a vast distance, as far as the eye can reach from the mast head; some of which have been computed to be above a mile long and 200 feet high above the surface of the water, which is considered as only one fourteenth of their extent under water. How amazingly great then must be the real bulk of such islands, or rather continents of ice! They have been found within 36° or 37° south of the equator, and 39° or 40° north. In the year 1805 from April to June they occurred more frequently in the Atlantic Ocean, and particularly near the banks of Newfoundland, than had ever been remembered be-

fore. The disasters occasioned by them among ships during the above period were fully detailed in the public prints, and are still fresh in remembrance, particularly those of the Jupiter, Capt. Law, from London, in latitude 44° 20′ longitude 49°, and the Sally, Capt. Bigby, latitude 42° 30′ longitude 50°, both of which vessels bilged and sunk, with a considerable part of the crews! A British packet foundered, and many other ships were greatly damaged by the ice. From observation it appears, that during the spring of 1805 from latitude 40° to 47° and from longitude 44° to 57° (a wide expanse of sea) the navigation of the Atlantic was peculiarly hazardous. The preceding winter indeed had been uncommonly severe, and the cold weather extended more than usual into the succeeding spring. Part of the ensuing summer however was remarkable for a high degree of heat, being at times from 90° to 96° of Fahrenheit's thermometer.

Respecting their origin the general opinion is, that they are gradually formed by accumulations of ice within the arctic and antarctic circles, and are carried by tides and currents to different latitudes. But if they are found, as Erwin and others alledge, not only in the Atlantic, but also in the Baltic, the Euxine, the Asiatic, and the Pacific oceans, how can we suppose them capable of traversing such temperate seas and warm regions, without undergoing a more speedy liquefaction? Hence the frozen seas of the arctic aud antarctic circles cannot be considered as the only sources where ice islands are exclusively generated; nor can the liquefaction of the polar ices explain the regular periodical return of the tides, as the Abbe St. Pierre fancied, when he vainly attempted to overturn the doctrine of solar and lunar influence, established by the immortal Newton.

The origin of ice islands therefore still remains in obscurity, and may possibly, at length, be found, where it was least suspected. If it be true, according to some late observations, that the temperature

of the sea decreases from its surface downwards so far as has yet been determined by the deepest soundings, where its coldness reaches the freezing point even of salt water, is it not probable that, at greater depths out of soundings it may be many degrees below the freezing point, and that where congelation is constantly going on, these enormous masses of ice may be gradually formed *stratum super stratum*, attaching themselves to the bottom till, loosened by currents or tides, they are detached, and being specifically lighter than water, like air balloons increasing in buoyancy in proportion to the increase of their surface, they will gradually rise, and at length rear their heads far above the surface? That here, floating in a warmer medium, with their summits exposed to sun and rain, the parts above water, according to the degree of latitude and temperature of the season, will gradually melt down to the water's edge, while the mass below, acquiring an increased specific gravity from the act of liquefaction above, and from stones or gravel brought up from below, will sink to the bottom?

Ice islands are not seen any where within the vicinity of the gulph stream for an obvious reason, viz. the superior warmth of its current. Shallows, as Dr. Franklin first demonstrated, are of a colder temperature than deep water. Is not this owing to their vicinity to rocky or earthy bottoms, which, being conductors, deprive the water of part of its heat? May not similar conducting bodies at the bottom of the deepest seas, which, for want of proper experiments, are wont to be pronounced unfathomable, produce similar effects? Thus the water over the banks of Newfoundland at 46 fathoms is generally found at 47°, yet a thermometer immersed in the belly of a cod fish just brought up marked 37°. This fact I had an opportunity of seeing verified in October 1803. But fishes being warmer than the medium in which they live, this fish being 10° colder than the water at the

surface must have come from a much colder region below. In a hot climate the surface of the sea was at 84°, while Capt. Ellis at the depth of 3000 feet marked the temperature at 53° and at 5,346 feet of line out, he tells us, the temperature appeared the same, but there is reason to believe such a vast weight of line must have floated the lead in a horizontal direction and drawn him into a considerable error. For Lord Mulgrave at the depth of 4,680 feet found the thermometer marked 26°, which is 6° below the freezing point of fresh water, and even one below that of the sea water itself.

By means of the marine bucket with valves accompanied with a thermometer as proposed by Dr. Hales, sea water may be taken up at various depths and its temperature examined. That its coldness increases at great depths has been ascertained, and well known to navigators in tropical seas in very hot seasons, where they draw it up for the purpose of making a cold bath, and for cooling their liquors.

As the summits of lofty mountains, even in temperate climates, are constantly covered with snow, and the atmosphere itself at the altitude of less than four miles from the earth, although exposed to the direct rays of the sun, is nevertheless the region of perpetual frost; and as nature pursues a simplicity and uniformity in her operations, why may not the bottom of the ocean, so far removed from the influence of the solar rays, be also, in certain latitudes, the seat of constant congelation? But the art of sounding, indeed, is still very imperfect, and the mysteries of the great deep remain to be explored by future researches.

But it may be objected, that as the sea to a certain depth is warmer than shallows, it must be uniformly so to the bottom in consequence of the central heat of the earth; otherwise whence proceed hot springs and volcanos? To which it may be replied, experiments have already discovered very different temperatures at different depths, though the temperature of the earth in the deepest mines is 52°, and has never

been found to exceed 53° that the most combustible materials contained in the bowels of the earth impart no sensible heat to the neighbouring strata till they are decomposed, and then probably may give rise to warm springs. Nor does a mass of gunpowder emit any heat till the moment of explosion. But effects of this nature are merely local, transitory, and circumscribed.

Besides, the received notion of central fire is entirely hypothetical, and apparently groundless, for hot and cold springs often issue from the same hill, and volcanoes have been known to burst forth from mountains covered with snow. The native heat of the earth and ocean then seems to be derived from a more steady, permanent cause, dependent solely on the sun, whose enlivening rays cheer all nature.

Were this source of heat totally withdrawn, all our rivers and the ocean itself would probably soon be converted into ice. Water by the mere absence of a certain portion of heat assumes a solid, crystalline form. Hence, by means of artificial cold, ice may be formed in the hot regions of the torrid zone.* Hence also in the frozen polar

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* The celebrated cavern of Grace Dieu in Besançon, 146 feet under ground, presents a singular and curious phenomenon. Within it in summer ice is formed in large quantities, and this ice diminishes at the approach of winter. "The air within," says M. C. Cadet, "did not feel colder to me, than that of the open atmosphere; nor does the water, which filters into it, freeze as it falls into a cavity, formed below in the ice; neither does the water seem very cold, when drank." As no natural philosopher has yet been able to explain this interesting phenomenon, he conjectures that the abundant aqueous evaporation of the bushy trees, with which it is surrounded, cooling the earth and air around the cavern during summer, tends to produce this effect, till they drop their foliage, when the cooling process of evaporation ceases. He thinks it somewhat similar to the operation of cooling liquors in hot countries, by means of water evaporating through porous jars.

Annales de Chimie 1803, p. 160.

regions ice may be deemed by the natives water in its natural state, and constituting a peculiar salt.

For according to the new chemistry, what is water, but a compound of vital and inflammable gas? Or, in other words, an oxyd of hydrogen? By the act of congelation it undergoes a decomposition, fresh water losing its atmospheric and carbonic gas, and sea water its saltness. That a mixture of hot and cold water has a strong tendency to restore an equilibrium is readily allowed, because the colder particles naturally fall downwards, while the warmer mount upwards; but the ocean, subjected to tides and currents, with conducting bodies interposed at different depths and distances, must still be liable to considerable variation in temperature, as has been fully ascertained; a circumstance of no small consequence to navigation, as will probably appear in the sequel.

These enormous masses of ice, during their gradual liquefaction and evaporation,* powerfully absorb a large portion of caloric (the principle of heat), while the copious exhalation, which ensues, meeting a frigid atmosphere, generates thick clouds and vapours; hence the increased cold and dense fogs, which generally surround them, and frequently envelop the ocean to a great distance, particularly over the banks of Newfoundland.

Final cause of ice islands.

Are these mountains of ice then formed only to infest the ocean, impede navigation, and produce melancholy disasters? Are these stupendous operations of nature alone destitute of utility to the

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* That ice evaporates in the low temperature of 31° even in the night with a N.E. wind to the amount of 110 grains in 9 hours appears from the experiments of Mr. J. Dalton. *See Nicholson's philosophical journal*, vol. vii. p. 15.

human race, and presented to their astonished eyes only to create terror and surprize? As no explanation of the final cause of these remarkable phenomena has hitherto even been attempted, it perhaps may be allowable in this place to offer a few conjectures. In the present chequered state of being, good and evil are every where blended, though the former is generally predominant. May we not suppose then, that these apparent evils are designed for some useful or beneficial purpose not yet discovered? Or, as Pope expresses it, "blessings in disguise?" That they are impediments to navigation cannot be denied; but it is no less certain, that by vigilance they may generally be evaded, and dangerous disasters prevented by due attention to the precautions hereafter to be mentioned.

As difficulties may be rendered useful to the prudent and enterprising, may not these grand obstacles serve to call forth the talents and exertions of our naval commanders and brave seamen, and inure them to encounter the dangers of the deep? affording also hints for improving navigation and the construction of ships destined to traverse the Atlantic and other seas, where ice islands abound? May not the gradual liquefaction of such vast masses of ice, divested of salt, add a large portion of fresh water to the ocean? And may not this occasionally be necessary to the well being of fishes and other marine animals, many of which at certain seasons delight to bask in fresh rivers? May not the melting ice by the action of the sun beams evolve copious streams of vital air, and thus contribute to the salubrity of the atmosphere? Finally then, may not the formation of ice islands be destined to the most important purposes, viz. the health, vigour, and refreshment of the animal and vegetable creation?

In hot and sultry climates ice is sought with avidity, not only as an article of exquisite luxury in elegant entertainments, but a most

grateful remedy in allaying thirst and assuaging intemperate heat in ardent and malignant fevers.

In Bengal ice is formed artificially, and rooms are cooled by the continued evaporation of cloths, frequently sprinkled with water. That the evaporation and liquefaction of ice islands may affect the temperature of the adjacent climates to a great extent cannot be doubted.* The variable winds waft the atmosphere that surrounds them far and wide, diffusing cool breezes along the coasts of the inland countries. Hence the spring and part of the summer of 1805 was cool and temperate, while the evaporation from the immense bodies of ice continued.† But after they were wholly dispersed, about the first of July the hot season commenced, and daily increased till the 10th, when my thermometer, in the shade, reached 96°, and continued vibrating between 84° and 90° till August 27, when it suddenly with a north-east wind dropped to 75°.

Method of warding off the dangerous effects of ice islands.

Having already in a former work pointed out the chief causes of shipwreck and the means of prevention,‡ the present subject being postponed now justly claims a separate discussion.

Whatever theory philosophers may adopt respecting the origin of ice islands, the principal object of this memoir is to propose a few simple rules, by which seamen may be enabled to steer clear of them.

1. In order to avoid them in northern voyages the ship ought to

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* Thus the wind, which passes over the polar ices, renders Siberia the coldest of inhabited countries. *Pennant's Arctic Zoology*, vol. i. p. 172.

† Accordingly the spring proved propitious to vegetation, as the crops of grain and herbage were allowed to be abundant, particularly through the Atlantic states.

‡ Prize essay on the preservation of shipwrecked mariners, second edition London, 1800.

bear to the southward of latitude 39, and in southern voyages the reverse even to within 36 degrees of the equator. This being the safest course, though at the expense of lengthening the voyage.

2. Ships destined to cross suspected seas, and particularly the banks of Newfoundland, in dark nights and thick fogs, demand peculiar circumspection, not only respecting the danger of striking against ice islands, but of running foul of other ships; and therefore ought to be well supplied with lamps with reflectors, during their dark and hazardous passage. The ship also ought to be uncommonly substantial, and the parts most liable to be struck, fortified in the best manner possible with a body of wool, hair, oakum, or other elastic substance, to enable the vessel to sustain, with impunity, any sudden or unexpected shock. On clear nights the ice islands are distinguishable at a considerable distance by gleams of light, reflected from their surface.

3. As the increased coldness of the water around ice islands depresses the thermometer, so the dense atmosphere above must raise the barometer, it certainly behoves commanders to have on board a set of accurate barometers and thermometers, at least two of each sort, and to mark the changes, as the sudden rising of the former and the fall of the latter might, either by night or day, or during the thickest fog, forewarn them of their approach to fields or islands of ice.

If we contemplate the dangers of navigation and the frequency of shipwrecks, particularly in the Atlantic ocean, where ships are sometimes surrounded by islands of ice, where rocks and shoals are often unnoticed, or erroneously laid down in the marine charts, and where the eddies and opposing current of the gulph stream, when entered unawares, often render the passage from Europe to America long and perilous, or in the opposite course so rapid as to outstrip the ordinary reckoning, surely when all these circumstances are considered we cannot too strongly recommend to all navigators the dili-

gent use of the thermometer, by which they may be timely forewarned of the approaching danger. It must be acknowledged however, that there are two or three circumstances, which form an exception to the general rule respecting the thermometer, which, when previously understood, can scarcely occasion any embarrassment. 1. It fails in rivers and capes. 2. Near sand banks, which rise considerably above the surface of the water, and which, on being heated by the sunbeams, impart an increased degree of warmth to the surrounding shoal water, and consequently cause the mercury to rise contrary to its wonted motion in soundings and shallow waters. 3. In marine currents, which, according to their course from warmer or colder climates, may produce a sudden and unexpected variation in the thermometer, though perfectly just to its principle of action. In other cases it marks the changes with the greatest accuracy. Thus the water out of soundings is always 8° or 10° warmer than within soundings. Thus also, the current of the gulph stream, from its superior warmth, raises the mercury from 16° to 24° higher than the adjacent water of the coast.* Accordingly the water over the grand bank of Newfoundland, from its superior coldness, depresses the mercury from 12° to 15° low-

* This remarkable stream is distinguishable not only by its warmth, which it retains in its course through the ocean for more than 330 leagues, almost to the banks of Newfoundland, where its condensed vapour adds to the fogs of that gloomy region. The weeds, brought down with it from its source in about 30 days, mark its course, and its water is never luminous in the night. The passage from Europe to America is expedited by avoiding to stem its stream, but from America to Europe by keeping in it. On this subject see Capt. Williams' experiments in three voyages across the Atlantic, who does not indeed appear to have met with ice islands, as he only just slightly mentions them. But his experiments, conducted with such uncommon attention, seem worthy the imitation of all navigators, and accordingly, in future, I mean to avail myself of their general result.

er than the adjacent deep water out of soundings. But the degree of depression in the vicinity of ice islands, though a matter of importance, which demands particular attention, seems to have been hitherto overlooked. The sea water in general, in point of temperature, near the surface, corresponds nearly with the temperature of the superincumbent atmosphere, varying a few degrees higher or lower according to climate and local circumstances, in summer the air being warmer than the sea, in winter the reverse; but the condensation of the atmosphere over mountains of ice, and its rarefaction over the gulph stream cannot but materially affect the barometer, as we know the sudden change of temperature in the water does the thermometer. Therefore in a matter of such consequence, and where the lives and property of so many persons are so deeply concerned, we cannot too earnestly recommend to all navigators, particularly in long and hazardous voyages, the joint use of both instruments, as a necessary part of their nautical apparatus. That the temperature of the atmosphere and of the ocean at the surface and at different depths should be daily examined by accurate experiments, and regularly noted in their journals.

Thus might these two simple instruments be rendered subservient to the improvement not only of meteorology and the theory of the ocean, but more particularly to the safety of navigation, by pointing out rocks, shoals, and ice islands, where sea charts fail, and where neither lunar tables nor even the magnetic needle itself can convey the smallest information.

Recapitulation and conclusion.

From what has been advanced it would appear, that ice islands present a new and ample field of inquiry, which is only just beginning to be explored.

2. That the origin, formation, and destination of ice islands, hitherto unknown, may now perhaps admit of a probable explanation, that may excite others to complete the discovery.

3. That the arctic regions *alone* give birth to ice islands, and the liquefaction of the polar ices to the tides, as has been supposed, seems highly improbable.

4. That the ice islands observed in the more temperate seas, where the temperature decreases downwards, may originate where least expected, viz. at the bottom; especially where rocks and other conducting bodies overspread the surface.

5. That the notion of central fire is groundless; and that objections, drawn from it, or volcanoes, are alike inadmissible.

6. That ice in the open air evaporates even below the point of congelation, and that evaporation generates cold and accumulates ice in the curious cave of Grace Dieu most in summer.

7. That the evils, occasionally produced by ice islands, are complained of, while their beneficial effects on the animal and vegetable creation have hitherto passed unnoticed.

8. That winds, blowing over them, temper the intense heat of summer in the adjacent climates.

9. That ice islands may be guarded against by vigilance, and by ships well constructed.

10. That the thermometer may be rendered preeminently useful in pointing out the approach of rocks, shoals, and shores; but particularly of ice islands and the Gulph stream.

11. That the barometer may also greatly contribute, and that these instruments should jointly constitute a part of the nautical apparatus, and daily observations be noted in the journals.

12. Finally, that by due attention to the above rules those dangerous obstacles to navigation may be detected, which elude the magnetic needle and all other instruments; and thus might the art of navigation be improved, science promoted, and many disasters prevented.

POSTSCRIPT.

SINCE writing the above, on being admonished that part of my paper had been anticipated by M. Peron, I hastened to peruse his memoir,* which had till now escaped my knowledge, or I should certainly have noticed it. Much credit indeed is due to M. Peron's assiduity in marking the temperature of the ocean four times a day; but his assertion, that its temperature increases in approaching continents or islands, is diametrically opposite to what I have observed, and also to the experiments of Dr. Franklin and some of the ablest English navigators. They had long before, with great care and accuracy, explored the ocean to a far greater depth than M. Peron, and discovered the increasing cold even to the freezing point of salt water. But what is singular, neither they nor M. Peron have from thence attempted to explain the formation of ice islands in temperate climates, or their final cause, or, what is of much greater importance, the best method of guarding vessels against their terrible effects, or of pointing out their approach in dark nights by the use of the barometer and thermometer. In short, except what has been mentioned as highly improbable, I find nothing in M. Peron's memoir, that was not discovered long before by the authors I have mentioned, and on whose accuracy I have depended as a foundation of the doctrine I have ventured to advance. In which it seems evident, that instead of my being anticipated by him, he has been anticipated by them; of which, however, this learned society, to whom I have the honor to addres it, will judge. Should it be deemed unsuitable to their designs in their ensuing volume, they will please to return it inclosed to the care of Mr. John Warder, Race street, Philadelphia.

* Annales de Museum vol. v. Paris, 1804.